**Carl Wieman**
Citizen Special

*Friday, November 09, 2007*

Science education and the weather have a lot in common: everybody complains, but nobody fixes. However, unlike with the weather, everyone seems convinced they know who is responsible for science education and who should fix it: Somebody other than me.

CREDIT: Reuters

Carl E. Wieman, who along with Eric Cornell and Germany's Wolfgang Ketterle won the 2001 Nobel Prize in physics, says mastering a science subject involves far more than simply acquiring information.

There is a long list of culprits people tend to blame: bad teachers and school systems, universities that care only about research and not teaching, classes that are too large, insufficient government support, the mental or moral decline of today's students, just to name a few. While most of these complaints are as ancient and unchanging as education itself, changes in the world around us have made it critically important that we get beyond the finger pointing and find ways to improve science education.

We face looming, global-scale environmental issues that are fundamentally technical and will reach a crises stage in the next few decades. If citizens are to understand and make wise decisions on these difficult issues, they must have far greater technical literacy. Also, the health of the modern knowledge-based economy is critically dependent on having a workforce with extensive scientific and technical skills.

So what can be done? I would suggest starting first with university and college science courses, although most people see this as the last place to start.

While I agree that K-to-12 science education is clearly important, serious change in teaching at that level is very complex because there are a host of stakeholders and constraints, including a well documented shortage of skilled K-to-12 science teachers. Most teachers, like most parents, leave university poorly connected to science, and they cannot help but convey this to young people.

In contrast, changing university teaching can be, in principle, as simple as instructors deciding to teach differently. But simple does not mean easy.

The greatest obstacle in science education improvement at the university level can be summed up in one commonly asked question: "Why should we change?" After all, universities have been teaching this way for hundreds of years and things seem to be OK; generations of scientists and engineers have been produced that get our bridges built and keep our high-tech companies in business.

The critical question I'd like to pose instead is: Are there opportunities to improve? The answer is a resounding yes. These opportunities have been revealed through advances over the past couple of decades in understanding how people learn.

Traditional lecture-centred classes were designed with the underlying assumption that learning about science is merely the transfer of information from the informed brain to the uninformed one; therefore, an unsuccessful transfer must surely indicate a deficiency in the uninformed brain. We now know that this assumption is quite incorrect.

A variety of research emerging from brain imaging and cognitive science laboratories and university science classrooms all clearly shows that mastering a science subject involves far more than simply acquiring information. It requires actually changing structures within the brain. Achieving the necessary structural changes requires the brain to be involved in very different mental processes than the ones employed in passively listening to a lecture or memorizing problem-solving recipes before an exam.

To master a science subject, the brain must be strenuously exerted toward understanding and applying the relevant knowledge in meaningful contexts, the way a muscle is developed through strenuous exertion.

Further insights on how university science can be improved are provided by other research which shows that most students are less interested in science and see it as having less value and relevance after completing an introductory university science course than before they started the course.

The exciting news is that these research advances have led to methods that result in far greater learning than the traditional lecture for nearly all students, and are found to be more rewarding for both the students and instructors.

These methods have the students intensely engaged in reasoning through challenging and authentic science problems, both in class and on homework. These require them to apply knowledge in creative ways to solve meaningful problems. They receive timely feedback to guide their thinking.

Essentially, rather than hearing about science, they are actually doing science on a small scale -- carrying out those mental exertions required for the brain to develop the ability to think like a scientist. When properly implemented, these methods have also been shown to convince students how scientific knowledge and reasoning can be useful and relevant in the real world around them.

In such a research-based course the instructors are no longer expensive dispensers of information.

Instead they are, first, educational designers who establish the goals and pose suitable problems to the students. With problems that are challenging but attainable, most students effectively develop the desired reasoning and analysis skills.

Second, the instructor is an intellectual guide who evaluates the students' thinking and coaches them as to how to improve. Through the use of low-cost technology and proper educational design, it has been shown that it is possible to do this timely evaluation and feedback even in large classes. So these methods are inherently no more expensive than current university teaching practices.

However, taking this scientific approach to teaching from prototype demonstrations to a scale where it is the norm in every university classroom won't be easy or cost free. It involves a substantial amount of development effort to create new educational materials and course designs and to help the faculty to learn to use them effectively.

The Science Education Initiative at UBC (www.cwsei.ubc.ca) is undertaking this broad development and implementation effort. The costs and challenges involved are not unlike what a company must do in retooling to produce a different, higher quality product line.

These costs are small however when weighed against the benefits that will result -- a more scientifically literate general public, better trained K-to-12 teachers, and more and better scientists.

***Carl Wieman**, a Nobel laureate in physics, is director of the Carl Wieman Science Education Initiative at the University of British Columbia.*